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W. B. Jeffreys
Heilbron O.R.C.
S.A. 1906

PLATES
OF
THE HEART,
ILLUSTRATIVE OF
THE CIRCULATION OF THE BLOOD;
AND THE
EFFECTS OF OXYGEN AIR ON THE BLOOD.

BY
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SEGNIS IRRITANT ANIMOS DEMISSA PER AUREM,
QUAM QUÆ SUNT OCULIS SUBJECTA FIDELIBUS ET QUÆ
IPSE SIBI TRADIT SPECTATOR.
HOR.

LONDON:

Printed by C. Whittingham,

FOR SYMONDS, PATERNOSTER-ROW; AND SOLD BY COX, ST. THOMAS'S STREET, BOROUGH; JOHNSON, ST. PAUL'S CHURCH-YARD; MURRAY AND HIGHLEY, FLEET-STREET;
BELL AND BRADFUTE, EDINBURGH; ARCHER, DUBLIN; CAMPBELL, PHILADELPHIA; AND ALLEN, NEW YORK.

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THESE PLATES

ARE,

WITH THE UTMOST RESPECT,

INSCRIBED TO

DR. HAIGHTON,

TEACHER OF PHYSIOLOGY AND MIDWIFERY AT GUY'S HOSPITAL;

TO

MR. CLINE AND MR. COOPER,

TEACHERS OF ANATOMY AT ST. THOMAS'S HOSPITAL;

TO

MR. ABERNETHY,

TEACHER OF ANATOMY AND PHYSIOLOGY AT ST. BARTHOLOMEW'S HOSPITAL;

TO

MR. CRUIKSHANK AND MR. WILSON,

TEACHERS OF ANATOMY AND PHYSIOLOGY IN THE SCHOOL FOUNDED BY THE LATE DR. HUNTER;

AND TO

MESSRS. WILLIAM AND THOMAS BLIZARD,

TEACHERS OF ANATOMY AND PHYSIOLOGY AT THE LONDON HOSPITAL.

DESCRIPTION OF THE PLATES.

THE CIRCULATION OF THE BLOOD.

THE ~~innocent~~ HARVEY, the pride of our country, was the discoverer of the circulation of the blood. "Seeing," says he, "that the blood passes from the arteries in abundance into the veins, unless these were to empty themselves, and the others to be re-filled, that ruptures of vessels every where would take place, which does not happen, I began to conjecture there must be a circular motion of the blood; but this doctrine was so *new* and *unheard of*, that I feared much detriment might arise from the envy of some, and that a number would take part against me, so much does custom and doctrine once received, and deeply rooted, pervert the judgment. However, my resolution was bent to set this doctrine forth, trusting in the candour of those who love and search after truth." In a letter to professor Riolan this great man says, "Since the publication of the circulation of the blood, almost no day has passed in which I have not heard both good and evil of my doctrine. Some say that this babe of mine is worthy to be fostered; and that I have by many observations, and ocular testimony, confirmed the circulation of the blood. Others think that it is not as yet sufficiently illustrated, and free from objections; and others again cry out, that I have affected a vain commendation of myself from dissecting of living animals, among which they deride my having made mention of frogs, mice, and other such contemptible creatures, and do not refrain from the most opprobrious language. It cannot be helped, cries Harvey, but that dogs will bark, and cynics pretend to mix with philosophers; but I shall take special care that they do not bite, and destroy with their dogs teeth the very marrow of truth. They rail against me, because I do not answer the surfeits they have belched up. Detractors, mimics of men; let them know, that I never intend to read works that can have nothing of solid sense in them, much less should I esteem them worthy of an answer. It would be unworthy of me to return opprobrious language for theirs. I shall do better, for *I will overcome opposition by truth*; and if they would consider with me the anatomy of the vilest insect, they would find a GOD equally in the humbler, as in the higher works of creation."

Such, however, was the power of prejudice, that it is observed that no physician passed the age of forty believed in his doctrine, and that his practice declined at the period when he published this ever memorable discovery.

The new doctrine at last getting into some vogue, the senior physicians, says Malpighi, were inflamed to such a pitch at Bononia, that in order to root out heretical innovations in philosophy and physic, they endeavoured to get an act passed, whereby every graduate should be obliged to take the following *additional clause* to his solemn oath on receiving his degree: "*You shall likewise swear that you will, with all your might (pro toto tui posse) preserve and defend the doctrines of HIPPOCRATES, ARISTOTLE, and GALEN, which are taught in this university, and have been approved of during a long series of ages; and that you will not permit their principles and conclusions to be overturned by any person whatsoever.*"

Dr. Harvey, a few years before his death, had the happiness, however, to find the clamours of ignorance, envy, and prejudice, silenced; and professional men grew at last ashamed to own, that they had ever combated or disbelieved the *circulation of the blood*.

The doctrine taught by Harvey was,

That all the veins of the body falling into two trunks, viz. the *ascending* (1), and *descending, cavæ* (2), empty themselves into the *right auricle* of the heart (3). The *right auricle* unloads into the *right ventricle* of the heart (4), which throws the blood through the *pulmonary artery* (5) into the *lungs*, by its two branches (6) (7), which go to the *right and left lobes*.

From the *lungs* the blood is brought back by the *four pulmonary veins* (8), (9), (10), (11), into the *left auricle* (12), and from thence it passes into the *left ventricle* (13), by which it is distributed through the body by means of the *aorta* (14), and its branches. These terminate in the *veins* of the body, which collect the blood, and bring it back to the heart by the two *cavæ* (1) (2). Or, in other words,

The heart is divided into two parts by a longitudinal separation. These two parts are formed into two cavities by a ligamentous and tendinous separation.

The *veins** enter the two *upper cavities*, or *auricles*, and the *arteries*† go out from the two *lower cavities*, or *ventricles*.

When the *auricles* contract, the blood is driven into the *ventricles*; and when *these* contract, it is forced into the *arteries*.

Then *commences*, in fact, the *double circulation of the blood*.—The *arteries*‡ contract, and the blood flows from the *right division of the heart through the lungs* to enter the *left division of the heart*: and from the *left division of the heart*, the blood passes *through the various parts of the body* to enter again the *right division of the heart*.

Such indeed are the *admirable organs* destined for the *circulation of the blood*. But how greatly does this imperfect sketch fall short of the reality! How in-

capable are these outlines of expressing the beauties of this noble subject!

There is in the consideration of *the organs* performing the circulation of the blood, an air of *grandeur* that seizes forcibly on the mind, and penetrates it with the highest admiration§.

Far less *magnificent* in its plans, less *skilful* in the execution of them, *hydraulics* offer us but *faint images* of this miracle, in those machines by means of which water is distributed into every quarter of a great city.

The works of the CREATOR must be compared to the *emanations* of the same *infinite mind*. Ever like himself, *he* has impressed on all *his* productions a character of nobleness and excellence, which demonstrate their *divine original*.

THE OFFICE OF THE LUNGS.

THE *lungs* are situated on the right and left side of the heart. It is divided into two *lobes*, and these are subdivided into *lobules*, three on the right side, and two on the left. The *trachea*, or wind-pipe, descends into the lungs, and forms innumerable *cells*, which have a communication with each other, and give to this viscus a honey-combed appearance. In the membranes of these cells are distributed the branches of the *two pulmonary arteries*, and *four* returning vessels, or *pulmonary veins*.

In the *lungs* the blood coming into contact with *atmospheric air*|| works many chemical alterations in it.

Here it is (in the cells of the lungs) that the dark blood, throwing off attenuated *carbon*, forms with the VITAL AIR of the atmosphere,—*fixed air*¶:

Here it is, that the purple blood parts with its *hydrogen*, which, uniting the VITAL AIR, forms—the *humid vapour* that issues from the mouth**.

And here it is, that the *dark blood* (having thrown off *hydrogen* and *carbon*) imbibes the VITAL AIR, which changes its *purple colour* to a *brilliant red*.

EXPERIMENTS TO PROVE THAT PURPLE VENAL BLOOD ABSORB VITAL AIR.

If blood be taken from a *vein*, it readily separates into two parts, a thin semi-transparent fluid called *serum*, and the *crassamentum*, floating on it.

This firm substance at first appears of a *dark purple colour inclining to black*, but soon it assumes on its

* Viz. the *two venæ cavæ* (1), (2), and the *four pulmonary veins* (8), (9), (10), (11).

† Viz. the *aorta* (14), and the *pulmonary artery* (5).

‡ When the large plates of the heart were shewn to that great architect Sir William Chambers, and the circulation explained, he held up his hands with astonishment and admiration.

§ The right side of the heart pulsates, although it receives only *venal blood*. To solve this difficulty we are obliged to use the word *sympathy*; thus, if the nostrils be irritated, the muscles of the diaphragm are thrown into spasmodic action, and an irritation of the stomach brings into action all the abdominal muscles. Thus a disease of the kidney is marked by a numbness along the thigh, a gall stone by vomiting, and a disease of the liver by pain on the scapula. Of the cause of this connexion we are ignorant, and therefore are reluctantly obliged to have recourse to the term *sympathy*.

|| Dr. Monro observes, that the water tortoise has very large lungs, consisting of larger vesicles than in land animals; and conjectures that this probably is the reason, why they bear to be longer without breathing, as they are provided with a larger quantity of that JE NE SCAI QUOI from the air, which is so necessary to life. “*Respiration* we cannot explain: we only know,” says Dr. Hunter, in his Introductory Lecture which he published in the year 1784, “that it is, *in fact*, essential and necessary to life. Notwithstanding this, when we “see all the other parts of the body, and their functions, so well accounted for, we cannot doubt but that *respiration* is so likewise. And “IF EVER we should be happy enough to find out clearly the object of this function, we shall, doubtless, as clearly see, that *this organ* is “as wisely contrived for an *important office*, as we now see the purpose and importance of the *heart*, and vascular system; which, till the “circulation of the blood was discovered, was wholly concealed from us.” If this learned teacher was to rise from the grave, I believe, no subject would give him higher delight than to behold, issuing from the furnaces of the chemist, a new and simple philosophy, which has clearly developed the *nature and necessity of respiration*.

¶ This is proved by making an expiration through a tube containing *lime-water*, which will become instantly *turbid*.—Or if black blood be confined in a phial containing *vital air*, the whole of *that air* will be converted into *fixed air*.

** This you may prove by placing venal blood in *vital air*, when the sides of the vessel will be covered with large drops of *water*.—Or if black blood be received into a phial containing *azotic air*, *ammoniac* will be formed, which was shewn by Bertholet to be nothing more than *hydrogen* combined with *azot*.

upper surface a bright scarlet appearance, resembling the blood contained within an artery.

To prove that this florid colour is owing to the absorption of VITAL AIR (one of the principles of common air), the illustrious Dr. Goodwin enclosed a quantity of vital air in a glass receiver inverted over quicksilver, and introduced into it four ounces of blood fresh drawn from the jugular vein of a sheep: the blood became instantly very florid, and the quicksilver seemed to ascend a little in the receiver. To ascertain this latter circumstance, I repeated, says he, the experiment three or four times; the change of colour in the blood was always very sudden, and after several minutes the quicksilver ascended two or three lines.

If oil be spread on the surface of the blood, which will prevent the contact of air, no such alteration as to colour takes place.

Girtanner, who turned his thoughts much to this subject, discovered that venal blood not only assumed a bright vermilion colour when exposed to vital air, but gave out carbon and hydrogen, which uniting with the vital air, formed fixed air* and water†, which was found on the surface of the quicksilver.

EXPERIMENTS TO PROVE THAT CRIMSON ARTERIAL BLOOD CONTAINS VITAL AIR.

The arterial blood from the carotid artery of a sheep was received into a bottle full of azotic air. The blood from a bright red shortly assumed the deep colour of venal blood. On opening the bottle the next day, the azotic air which it before contained was found mixed with vital air, so that an animal could live in it, and a candle burnt in it for near two minutes.

This experiment proves decisively that arterial blood contains vital air, and that as soon as it parts with this air it then re-assumes the true venal character.

The arterial blood of the carotid artery of a sheep was received into a bottle full of nitrous air. The blood assumed a green colour‡ upon the surface. A small quantity of greenish serum was separated. The day after, on opening the bottle, the vapour of nitrous acid was observed by all who were present.

* Charcoal and oxygen air.

The presence of fixed air is ascertained by lime water; for water dissolves lime, and holds it suspended. The solution then appears perfectly clear and bright. If any fixed air comes into contact with the water, the carbonic acid seizes on the lime, and makes with it a combination insoluble in water. The lime, in that case, is visible in the water. Lime water is therefore a test of the presence of fixed or carbonic acid air.

† Hydrogen and oxygen.

‡ Dr. Girtanner having injected some nitrous air into the veins of a dog, when it came into contact with the common air admitted into the lungs, nitrous acid was formed, and the lungs assumed in consequence a greenish hue. The blood returned by the veins to the heart was found black.

§ Vide Medical Extracts, Fourth Edition, Vol. I. Sect. XIV. An account of Dr. Priestley's forming of Nitrous Air.

|| This experiment is related in his treatise on the recovery of drowned persons. A similar experiment to this was performed by Hook before the Royal Society an hundred years ago, when an animal, whose heart was exposed to view, was kept alive a whole hour by the inflation of its lungs. When this was omitted, the heart began to beat slower, and soon ceased all action, the eyes sunk, and the animal became convulsed; but all these symptoms disappeared as soon as the lungs became again inflated with air. An experiment of the same kind is also related by the illustrious Dr. Goodwin, which shewed most evidently the connexion of respiration with the colour of the blood and action of the heart.

¶ Vide outline of the Heart, figure (5).

** Vide outline of the Heart, figures (8), (9), (10), (11).

Here then is an experiment which also proves the presence of vital air in the arterial blood; since it is from this circumstance alone that it is capable of changing nitrous air into nitrous acid§.

JOHN HUNTER'S CELEBRATED EXPERIMENT.

But that no possible doubt might exist, that vital air is imbibed by the blood in the lungs, we shall relate the experiment of John Hunter||. He opened the chest of a living dog.

The LUNGS and HEART were then exposed to view.

The blood, which was driven from the right ventricle of the heart into the pulmonary artery¶, appeared of a dark venous complexion.

It certainly was a striking spectacle to observe the black blood, as it returned from the lungs by the four pulmonary veins** of the lungs, in its passage to the left auricle of the heart, appear of a bright vermilion colour.

It was soon found necessary to inflate the lungs by artificial means.

If at any time this was intermitted, the blood in the four pulmonary veins appeared of a dark purple or modena colour, and the left division of the Heart receiving black blood, a diminution of the pulsations of the heart and arteries took place, and in a little time all their actions ceased.

But if at this time the lungs were made by the inflation of common air alternately to collapse and distend, the blood in the pulmonary vessels regained its former crimson colour, and the action of the heart and arteries was excited anew.

Thus, if we open the breast of a frog, and stop the trachea, or windpipe, we observe, first, its pulmonic blood florid, and the heart beating strongly; secondly, some time after, the pulmonic blood has become of a dark colour, and the heart's motion has grown languid; after this, the pulmonic blood becomes black, and the pulsation of the heart ceases; and lastly, the trachea of the frog being untied, and the creature allowed to breathe again, the blood becomes crimson, and the heart acts with its pristine vigour.

OF THE
PULSATION OF THE HEART AND ARTERIES,
AS DEPENDANT UPON VITAL AIR.

HINC quoque apparet sanguinis *principalitas*, quod *pulsus ex eo ortum ducat*. Nec sanguis solum pars primigenia et principalis dicendus est, quod ab eo motus pulsusque principium orietur; sed etiam quia in eo primum *calor animalis* innascitur, *spiritus vitalis* ingeneratur, et *anima ipsa* consistit. HARV. Exer. 51.

Hence also appears the *pre-eminence* of the blood, that the *pulsation* of the *heart* and *arteries* owes its *origin* to it. Nor is the blood to be called the *first mover* and *pre-eminent* for this alone, but because from it springs the *vital heat*, the *animal spirits*, and life itself. HARVEY's fifty-first enquiry.

How infinitely near does the immortal HARVEY approach the truth; and yet, I believe, he had not the most *distant conception*, that VITAL AIR was the *principle* from whose *benign influence* all these wonderful phenomena arise.

It is the study of air, and aerial fluids, that has brought to light all the beautiful discoveries which modern physiology can boast of.

In these Plates it was shewn, that the blood is *amid* of a rich *vermilious* colour in the *arteries*, and of a strong *purple* colour in the *veins*. When Hunter opened the thorax of a living dog, the lungs being collapsed, the heart soon ceased to play, the animal then languished, and seemed expiring, but was revived again when *air* was blown into his lungs: then began again the motion of the heart; the blood receiving the stimulating influence of *vital air*, acted on the left side of the heart, and the right side moved in sympathy, and the circulation was excited anew, and life continued. Now, this change in the motion of the heart happening so plainly from access of *air*, is a circumstance of the most interesting nature, and obliges us to look into the doctrines of chemistry for the solution of a phænomenon to which there is in the whole animal œconomy nothing to be compared.

On this occasion it is obvious to remark the im-

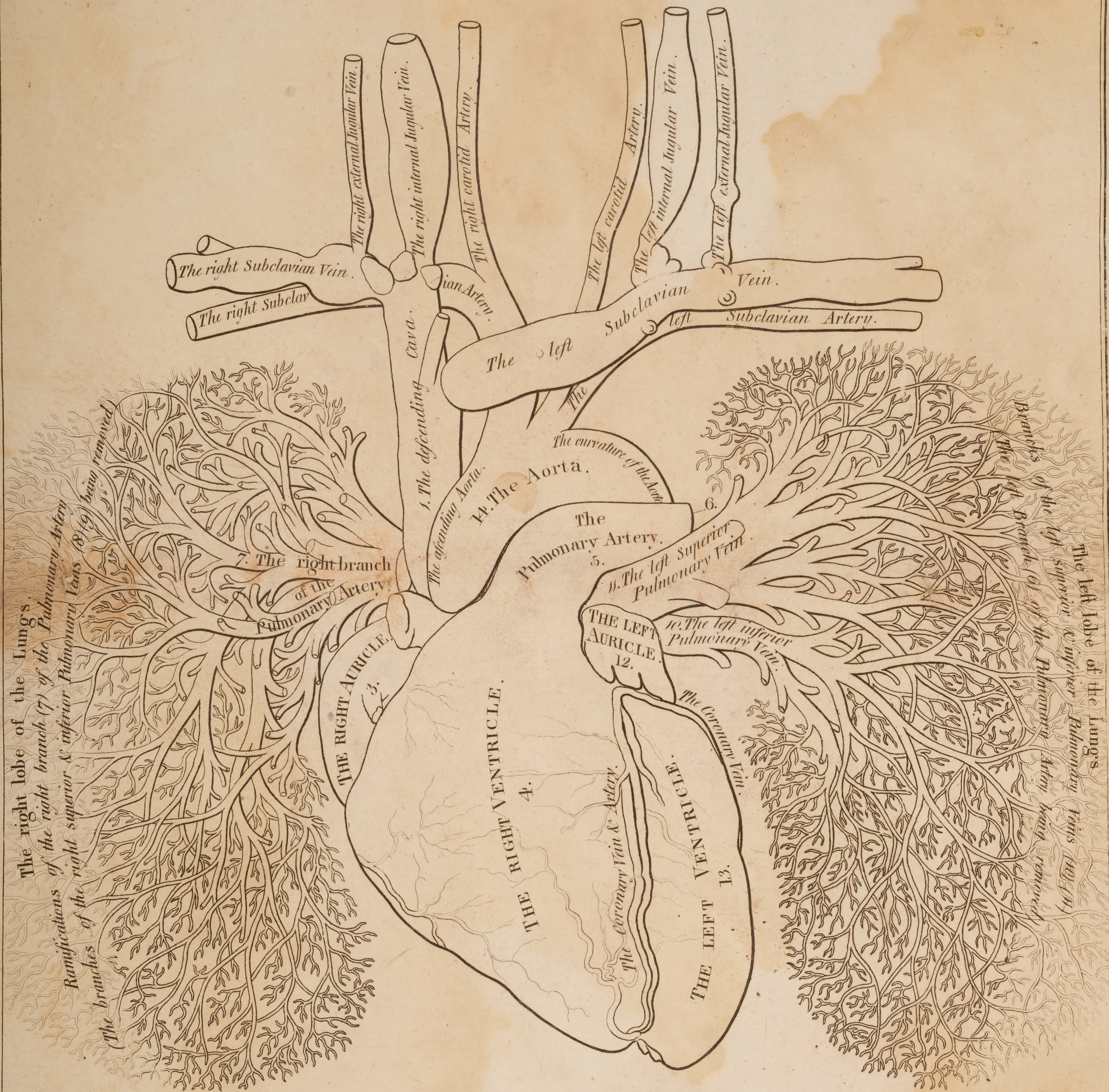
portance of the LUNGS; we perceive that the blood, every time it is *returned* to the *right ventricle* of the *heart*, is directly dispersed through the *lungs*, and *immediately re-conveyed to the heart*, before it is *permitted to begin a new circulation*; I may add, before it is *capable* of performing a *new circulation*: for had there been no real necessity, we may boldly assert, this operation of the blood, *passing from the right side of the heart through the lungs to the left*, would never have taken place. In the study of nature, throughout all her works, however *complex* the machine, the *utility* of each part ever claims the admiration of the speculative mind. This observation is beautifully illustrated on the present occasion; and I believe it will be admitted by every one, that the blood, after having performed *one round* throughout the animal œconomy, undergoes some *new and important change*, in its *transit through the lungs*, essentially requisite to support a *second circulation*. This change is certainly the *oxydation* of the blood; and we should expect, if *oxygen* be the natural stimulus* to the heart and arteries, that their pulsation would be in proportion as the blood had access to *impr. 10. 11. 12.* That this is really the case, appears from the following experiment, made before a most respectable society of gentlemen, who met once a week at Dr. Higgins's for the purpose of making philosophical experiments. Although Mr. Taylor was not more than 22 years of age, his natural pulse was only 64 previous to the experiment we are about to relate. During the inhalation of 19 pints of *vital air*, his pulse, as Dr. Higgins remarked, was quickened to 90 *beats in a minute*, and was considerably increased in *fulness* and *strength*. The vessel being immediately charged again with 19 pints of pure *oxygen gas*, he respired these also, and consumed them entirely in six minutes. His pulse was in consequence increased to 120 *beats in a minute*, and was *vigorous withal*†.

* As a negative proof, we have those experiments where persons have breathed a reduced atmosphere. One consumptive patient, contrary to my judgment, says Dr. Beddoes, used to inhale at times air wholly deprived of *oxygen*. During this process I have felt the pulse nearly "*obliterated*." He loved to indulge it, and describes the incipient insensibility produced on him as a state highly delightful. Vide Dr. Beddoes's *Observations*, p. 30.

† See *Minutes of the Society for Philosophical Experiments*, p. 146.



THE FRONT VIEW OF THE HEART



A FRONT VIEW OF THE HEART



To show the Circulation, and the effect of Vital Air on the blood



THE BACK VIEW OF THE HEART

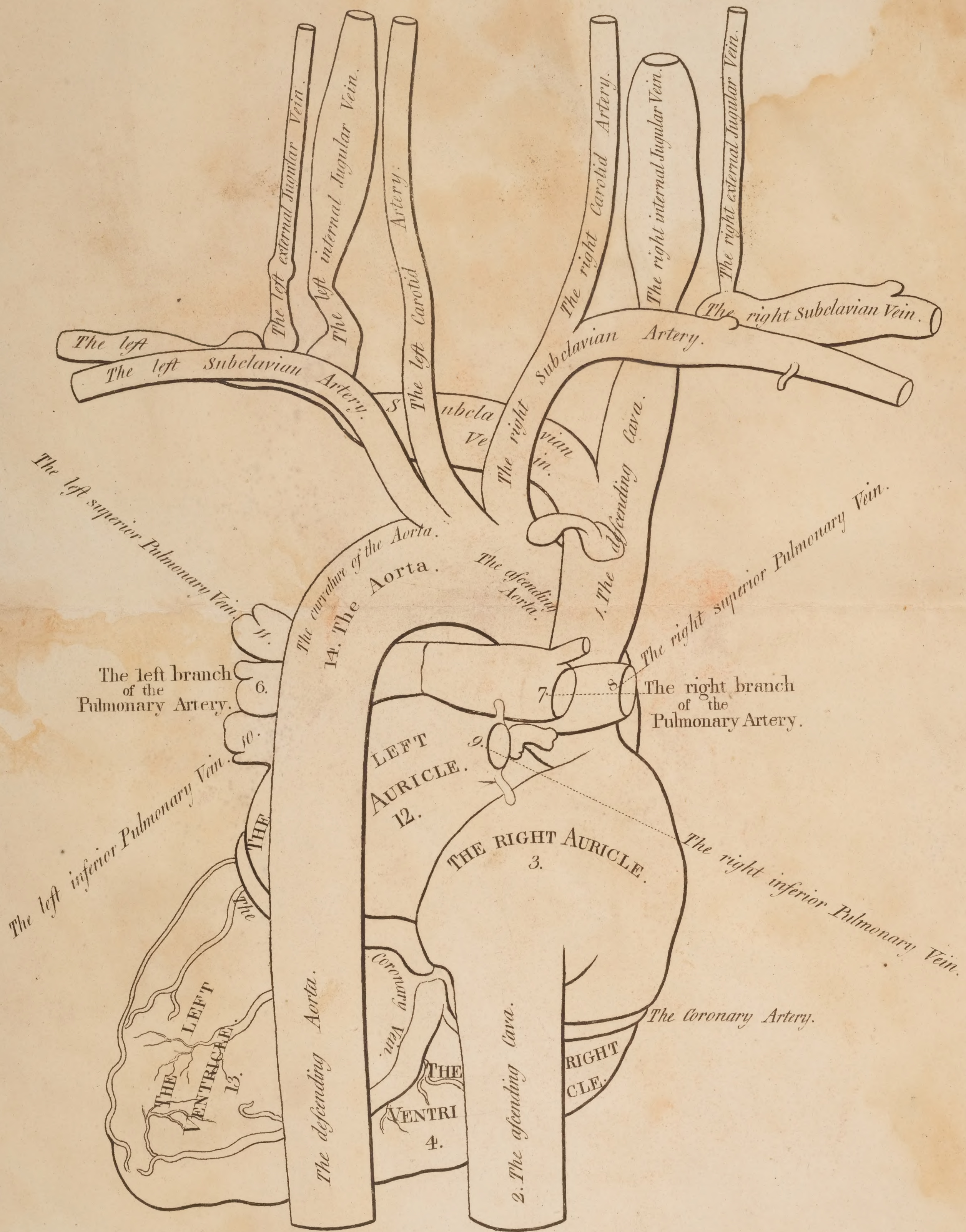


PLATE I.

A BACK VIEW OF THE HEART



To show the Circulation, and the effect of Vital Air on the blood.

